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Film-wise condensation characteristics at liquid nitrogen temperatures

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Film-wise condensation at liquid nitrogen temperatures is of great interest for applications in condenser/vaporizer for cryogenic air separation. Presently, very few data are available for the two-phase flow pattern and heat transfer in the nitrogen vapor condensation process. Experiments were implemented to obtain full insights into two-phase flow pattern and heat transfer characteristics at such low-temperature, which is visualized with high-speed photography while the temperature difference and heat exchange rate are measured. We studied condensation in various vertical plate fin passages as well as on the vertical wall. It is found that the experimental results of the relations between the heat exchange rate and the temperature difference about condensation on the vertical wall demonstrate a reasonable agreement with those predicted by Nusselt's theory. Different from condensation on the vertical wall, condensation in the fin passages becomes complicated because of effects from conduction heat transfer between ribs and substrate, variable film thickness along the fin, and surface tension of liquid nitrogen. Combined with numerical simulations, the correlation with the heat transfer coefficient is provided for condensation in the vertical plate fin passages. The comparison between the theoretical and experimental results will be presented. The results of this work will benefit the heat exchanger design of large-scale liquefaction to enhance the heat and mass transfer per unit volume.

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